

# PATENT ABSTRACTS OF JAPAN

(11)Publication number : 06-159205

(43)Date of publication of application : 07.06.1994

(51)Int.CI.

F02N 15/02

(21)Application number : 05-194934

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(22)Date of filing : 05.08.1993

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(30)Priority

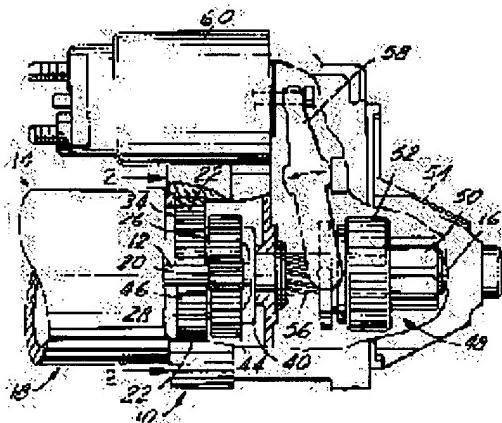
Priority number : 92 925155 Priority date : 06.08.1992 Priority country : US

## (54) COMPOUND PLANETARY GEAR APPARATUS

### (57)Abstract:

**PURPOSE:** To provide a compound planetary gear apparatus comprising smaller and lighter components for a starter motor of a vehicle.

**CONSTITUTION:** An apparatus comprises a pinion 20 mounted on an armature shaft 12, a relatively stationary ring gear 22, a plurality of planetary shafts 26, 28, and a plurality of planetary gear sets. Each of the planetary shafts is connected to an output shaft 16 and is orbitable about the armature shaft 12. Each planetary gear set includes two planetary gears mounted on an associated planet shaft. One of the planet gears engages the pinion 20 so that the rotation of the pinion is transferred to the first planet gear 44. The other planet gear 46 is rotatable with the first planet gear, and engages a ring gear 22 so that the associated planet shaft orbits the armature shaft and imparts rotation to the output shaft 16 sufficient to start the engine.



## LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

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**CLAIMS**

[Claim(s)]

[Claim 1] In a compound epicyclic gear drive for a Starter motor of an automobile A pivotable armature shaft, In order to connect with said power shaft and to deliver rotation a power shaft, a pinion attached in said armature shaft fixed, and a ring gear stationed around an armature shaft to a power shaft Two or more planet shafts with which each rides on the surroundings of an armature shaft into orbit, Are two or more epicyclic gear sets, the each is the 1st epicyclic gear attached in a correspondence planet shaft, and this engages with said pinion. The 1st epicyclic gear which can transmit rotation of an armature shaft to the 1st epicyclic gear, Are the 2nd epicyclic gear attached in a correspondence planet shaft, and this engages with said ring gear. A compound epicyclic gear drive characterized by including two or more of the epicyclic gear sets containing the 2nd epicyclic gear which can put a corresponding planet shaft on track around an armature shaft, and can transmit rotation to a power shaft.

[Claim 2] A compound epicyclic gear drive with which said ring gear is attached in housing fixed in equipment according to claim 1.

[Claim 3] A compound epicyclic gear drive with which said 1st epicyclic gear is being fixed to relative rotation about the 2nd epicyclic gear in equipment according to claim 1.

[Claim 4] A compound epicyclic gear drive with which said 1st epicyclic gear is being fixed to the 2nd epicyclic gear in equipment according to claim 3.

[Claim 5] A compound epicyclic gear drive attached in a planet shaft to which said 1st epicyclic gear is equivalent in pivotable in equipment according to claim 1.

[Claim 6] A compound epicyclic gear drive attached in a planet shaft to which said 2nd epicyclic gear is equivalent in pivotable in equipment according to claim 1.

[Claim 7] A compound epicyclic gear drive with which said ring gear is stationed in the said heart around an armature shaft in equipment according to claim 1.

[Claim 8] In equipment according to claim 1, said 1st epicyclic gear has the 1st diameter, said 2nd epicyclic gear has the 2nd diameter, and it is a compound epicyclic gear drive with said 1st larger diameter than the 2nd diameter.

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**DETAILED DESCRIPTION****[Detailed Description of the Invention]**

[0001]

[Industrial Application] This invention relates to the Starter motor for an automobile, and relates to a Starter motor with a compound epicyclic reduction gear especially.

[0002]

[Description of the Prior Art] The starting system of the Oita section for an internal combustion engine contains the direct-current Starter motor of a dc-battery drive. Said Starter motor can obtain the speed of a bigger armature shaft than about 80 thru/or 200 rotations per minute about per minute 60 thru/or 100 rotations, and a diesel power plant about a jump-spark-ignition engine to a rotational speed required to start an engine, i.e., a general target. However, since torque required to start an engine is larger than the torque which the armature of a Starter motor can generate, in order to change the speed of a Starter motor into the torque which increased, a certain equipment must be formed.

[0003]

[Problem(s) to be Solved by the Invention] In order that the Starter motor of the automobile of a conventional type may decrease the speed of an armature shaft and may increase torque available for engine starting corresponding to it, the single epicyclic gear set is used for it. Typically, this gear set consists of a pivotable pinion and at least one epicyclic gear which engages with both said pinion and ring gear with the ring gear fixed to the starter motor case, and an armature shaft. For example, it is good to refer to United States Patent [ / else / Colvin ] 4,412,457th. With the gear's relative diameter and the number of each gear teeth, said single epicyclic gear set makes the torque of the power shaft to the armature shaft of a Starter motor increase, and decreases the speed. Thus, the Starter motor equipped with the single epicyclic gear set is a direct drive, i.e., an output equivalent to a Starter motor without gear moderation can be generated, and it can make the construct of a motor coincidence more at a small size and a twist light weight.

[0004] The still more complicated compound epicyclic gear drive for the wide range purpose of use is proposed.

Typically, these layout has 2 or the epicyclic gear beyond it attached in the common shaft. For example, the compound EPISAIKURU gear device for using for the servo control device of a type used for the 3,081,648th computer of United States Patent by DEYUA, a navigation control metering device and a guidance control unit, and its similar equipment is taught. Moreover, the use of a compound epicyclic gear drive for energizing an airplane construct like the flap of the 3,640,150th aerofoil of United States Patent or a wheel-well door which the hinge attached is indicated. [ / else / liner ]

[0005] Also in order to use for the Starter motor of an automobile, the compound epicyclic gear drive is proposed. For example, United States Patent 4,573,364th by GIBAN is indicating the starter driving gear of gear moderation with which the sun gear which became a main shaft and integral construction drives some epicyclic gears. The 1st epicyclic gear and the same axle epicyclic gear of the 2nd set mesh with the gear tooth of the gear of a driven shaft, and a driven shaft is driven by it.

[0006]

[Means for Solving the Problem] This invention offers a compound epicyclic gear drive with which it was improved for transmitting rotation to a power shaft from an armature shaft of a Starter motor of an automobile, in order to put an engine into operation. Said equipment includes a ring gear which stood it still relatively [ pinion / which was attached in an armature shaft ], two or more planet shafts, and two or more epicyclic gear sets. Each planet shaft is connected with a power shaft, and can get off the ground around an armature shaft. Each epicyclic gear set has two epicyclic gears attached in a related planet shaft. One of said the epicyclic gears engages with a pinion, and it transmits rotation of a pinion to the 1st epicyclic gear. It can rotate with the 1st epicyclic gear, other epicyclic gears engage with a ring gear, a related planet shaft is put on track around an armature shaft, and sufficient rotation to start an engine is transmitted to a power shaft.

[0007] Therefore, the purpose of this invention is equipment of a type mentioned above, and it is in offering more efficient equipment which can obtain large gear moderation rather than being obtained from a single epicyclic gear set between an armature shaft of a motor, and a power shaft.

[0008] Other purposes of this invention are equipment of a type mentioned above, and are to offer equipment with a bigger gear reduction gear ratio.

[0009] Other purposes of this invention are equipment of a type mentioned above, and are to offer a smaller and more nearly lightweight motor armature and motor field components.

[0010] The purpose of further others of this invention is equipment of a type mentioned above, and is to offer equipment which maintains an output equivalent to a Starter motor of single epicyclic gear moderation of a direct drive.

[0011] These of this invention and the other purposes, the feature, and an advantage will become clear easily from detailed explanation of the following about the best gestalt for carrying out this invention, referring to an accompanying drawing.

[0012]

[Example] The desirable example of this invention is explained referring to a drawing. Drawing 1 and drawing 2 show the compound epicyclic gear drive 10, and this is for transmitting rotation to a power shaft 16 from the armature shaft 12 of Starter motor 14 of a motor vehicle. After that, as rotation of a power shaft 16 is transmitted to the crankshaft of an automobile engine (not shown) and is mentioned later, it puts an engine into operation.

[0013] The motor case 18 of Starter motor 14 is supporting in it the field coil or permanent magnet of a series of field generators, for example, the conventional type known well. When the ignition switch of a motor vehicle is turned to a starting location as known for this industry, said field generator acts so that the armature shaft 12 may be rotated comparatively at high speed.

[0014] Said compound epicyclic gear drive 10 consists of a pinion 10, the ring gear 22, two or more planet shafts 24, 26, 28, and 30, and two or more epicyclic gear sets 32, 34, 36, and 38. A pinion 20 will be comparatively rotated with the armature shaft 12 at high speed, if it is attached in the armature shaft 12 fixed, therefore an ignition switch is turned to a starting location. The ring gear 22 is attached in the housing 18 of a motor fixed, therefore to rotation of the armature shaft 12, stands it still and is held. Speaking typically, the diameter of a motor case 18 being about 3 inches (7.62cm), and holding the ring gear 22 stationed in the said heart around the armature shaft 12.

[0015] Each planet shafts 24, 26, 28, and 30 are being fixed to the board member 42 which became the end and integral construction of a power shaft 16. Said board member 40 is pivotable in the motor case 18, and the planet shafts 24, 26, 28, and 30 were supported, therefore each shaft has extended even at the point between the armature shaft 12 and the ring gear 22. Each planet shafts 24, 26, 28, and 30 can get off the ground around the armature shaft 12, if the board member 40 and a power shaft 16 rotate. Although it has four planet shafts which the example shown in drawing 1 and drawing 2 is the surroundings of the armature shaft 12, and have been arranged in equiangular, needing only a single planet shaft for demonstrating the function of this invention should be understood.

[0016] Said epicyclic gear sets 32, 34, 36, and 38 are attached on the planet shafts 24, 26, 28, and 30, and are supported by them. Each epicyclic gear sets 32, 34, 36, and 38 consist of a set of two epicyclic gears. If the epicyclic gear set 36 is referred to for explanation, this consists of the 1st epicyclic gear 44 and the 2nd epicyclic gear 46 which were attached in the planet shaft 28.

[0017] The 1st epicyclic gear 44 is attached in the planet shaft 28 in pivotable by the bearing pushed in into the 1st epicyclic gear 44. The 1st epicyclic gear 44 engages with a pinion 20, and rotation of the armature shaft 12 is transmitted to the 1st epicyclic gear 44. It is pivotable together around axis of rotation which the 2nd epicyclic gear 46 is similarly attached in the planet shaft 28 in pivotable, is being fixed also to the 1st epicyclic gear 44, therefore was demarcated by the planet shaft 28. Since the 2nd epicyclic gear 46 has a diameter smaller than the diameter of the 1st epicyclic gear 44 and the 2nd epicyclic gear 46 is engaging with the ring gear 22 in pivotable, the planet shaft 28 drives the board member 40, and it and the integral-construction-power shaft 16.

[0018] Or in this industry, it is directly fixed about the planet shaft 28, and, probably, the 1st epicyclic gear 44 and the 2nd epicyclic gear 46 are known by preventing also from rotating relatively to the planet shaft 28. The planet shaft 28 and the other planet shafts 24, 26, and 30 will be supported in pivotable on the board member 40 of a power shaft 16.

[0019] In actuation, rotation and torque of the armature shaft 12 are transmitted to the 1st epicyclic gear 44 and the 1st epicyclic gear of others of the gear sets 32, 34, and 38 from a pinion 20, and generate speed change which is proportional to the gear's relative diameter and each gear's number of teeth from the armature shaft 12 to an epicyclic gear set. The 1st epicyclic gear 44 and the quiescence ring gear [ the 2nd epicyclic gear 46 rotated at the same speed ] 22 are contacted, and it moves to a circumferencial direction along with it. Therefore, the compound epicyclic gear sets 32, 34, 36, and 38 rotate around the axis of the planet shaft in which they are attached, and the planet shafts 24, 26, 28, and

30 rotate them around a pinion 20 and a power shaft 16 further. Thus, movement and torque are transmitted to a power shaft 16.

[0020] The starter driving gear 48 consists of a pinion 50 and a clutch 52 as shown in drawing 1, and as the former shows in this industry. A pinion 50 is driven by the clutch 52 which it is arranged in movable on a power shaft 16, and driven by it. The flywheel (not shown) attached in the engine which it is going to put into operation, and engagement are possible for a pinion 50. For this purpose, the edge 54 of a motor case 18 has the opening (not shown) for containing the engagement section of a pinion 50 and an engine flywheel as known for this industry. The spiral spline 56 is formed in the power shaft 16 again, and it cooperates with the agreement-spiral sulcus in a clutch 52, and when the starter driving gear 48 is moved for a while in the direction of an axis by the engagement lever 58 of a solenoid 60 about a power shaft 16, the starter driving gear 48 is always rotated for a while. When the starter driving gear 48 is moved in the direction of an axis, a pinion 50 is made to engage with an engine flywheel.

[0021] The compound epicyclic gear drive by this invention sets the speed reduction gear ratio of the armature shaft 12 and a power shaft 16 to about 9.5 thru/or 1 compared with a reduction gear ratio called typical about 4.36 which can be obtained from a single epicyclic gear set thru/or 1. he should understand that the reduction gear ratio by this invention is changeable by changing each gear's number of teeth, and (or) the gear's diameter.

[0022] The compound epicyclic gear drive by this invention generates the output torque of about 10 thru/or 12 feet pounds (1.36-1.63 kg-m), and the peaking capacity of about 1 thru/or 2kw(s), and this can be equal to the output torque and output which are obtained from the Starter motor slowed down by the direct drive or the conventional single epicyclic gear. Furthermore, the construct of this invention is lightweight and more smaller than the construct of a direct drive or the single epicyclic gear device of a conventional type.

[0023] Although it is shown here and the gestalt of indicated this invention constitutes the desirable example of this invention, it should be understood that they are not what is going to explain all the gestalten that may exist. Moreover, it is a term for explanation rather than it limits the term used, and it should also be understood that various kinds of change can be made, without deviating from the pneuma and the range of this invention which were indicated.

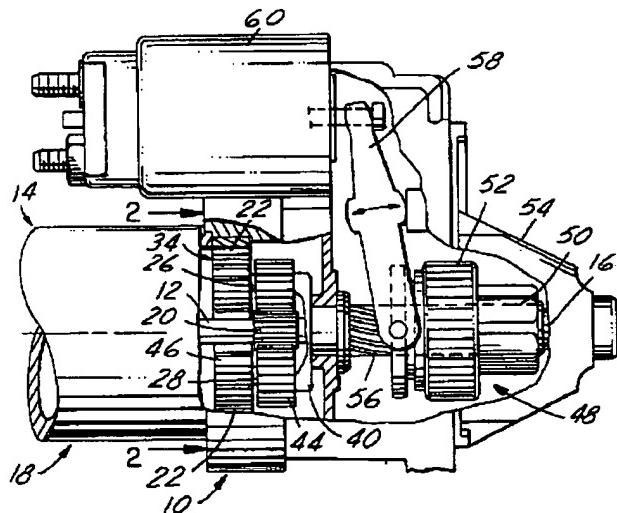
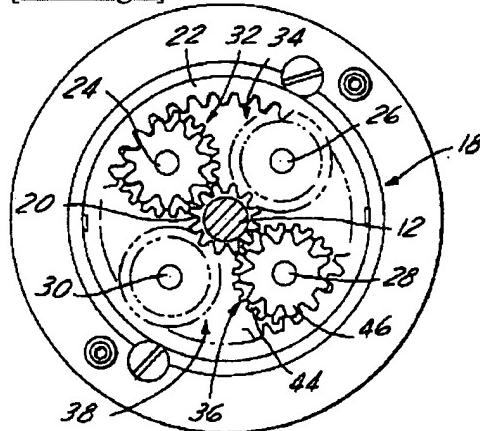
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**DRAWINGS****[Drawing 1]****[Drawing 2]**

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